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Parental (non-)pain attending verbalizations moderate the relationship between child attention and memory bias for pain

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Abstract

Background: Children's negatively biased pain-related memories (i.e. recalling pain as being more intense or fearful than initially reported) have been recognized as a key factor in explaining child pain development. While mechanisms underlying children's pain memory development remain poorly understood, attention biases and parent language have been implicated in conceptual models. This study examined the association between child pain-related attention and memory biases and the moderating role of parental pain and non-pain attending verbalizations.

Methods: Participants were 51 school children and one of their parents. Probability of initial fixation and gaze duration to pain were assessed using eye tracking methodology. Children performed a cold pressor task (CPT) and reported on experienced pain intensity and pain-related fear. A 3-minute parent–child interaction upon CPT completion allowed measurement of parental pain and non-pain attending verbalizations. Children's pain-related memories were elicited 2 weeks later.

Results: Findings indicated that the relationship between maintained attention to pain and fear memory bias was moderated by parental non-pain attending verbalizations such that higher gaze duration bias was positively associated with fear memory bias but only among children whose parents demonstrated low levels of non-pain attending verbalizations. The opposite pattern was observed for children whose parents showed high levels of non-pain attending verbalizations. No such effects were observed for child initial attention bias to pain, memory bias for pain and parental pain attending verbalizations.

Conclusions: Findings highlight the importance of parental and child pain-related variables as well as their interaction in understanding negatively biased pain-related memories.

Significance: This study on child pain memories is the first to highlight that characteristics of the social context, such as parental (non-)pain-related verbalizations, as well as factors related to the intra-individual experience of pain, such as child attention bias to pain, should be studied jointly, as they interact with each other in their effect on the emergence of negatively biased memories of painful events.

1 | INTRODUCTION

Children's negatively biased memories for pain (i.e. recalling pain as being more intense or fearful than initially reported) have been identified as key factors in worsening child pain development (Noel, Palermo, Chambers, Taddio, & Hermann, 2015; Noel, Rabbits, Tai, & Palermo, 2015). Indeed, child pain memory bias contributes, more than children's initial report of pain, to increased pain and fear during subsequent pain experiences (Chen, Zeltzer, Craske, & Katz, 2000; Noel, Chambers, McGrath, Klein, & Stewart, 2012a; Noel, Rabbits, Fales, Chorney, & Palermo, 2017). Conversely, accurate or positively biased pain memories contribute to improved pain outcomes (Chen, Zeltzer, Craske, & Katz, 1999; Chen et al., 2000; Noel et al., 2012a). Despite its clinical importances (Pate, Blount, Cohen, & Smith, 1996), mechanisms by which pain-related memories develop remain poorly understood (Noel, Chambers, Petter, et al., 2012; Noel, Palermo, et al., 2015).

Drawing upon attentional theories in the field of psychopathology, which posit that memory biases towards threat exist because individuals selectively encode and dwell upon threatening information, as well as conceptual models of pain memory development (Cowan, 1998; Noel, Chambers, Petter, et al., 2012), child *attention biases* may be vital. Pain-related attention biases have been implicated in child pain development (Van Ryckeghem et al., 2013; Vervoort, Trost, & Van Ryckeghem, 2013) and are likely pertinent in the context of child pain-related memories. Indeed, both attention and memory biases have been observed in the context of paediatric pain, particularly when pain is perceived as threatening (Noel, Rabbits, et al., 2015; Vervoort, Trost, & Van Ryckeghem, 2013), suggesting that both biases are linked (Noel, Chambers, McGrath, Klein, & Stewart, 2012b; Noel, Rabbits, et al., 2015).

Parental *pain attending* verbalizations (i.e. talk that focuses upon the child's pain, and considered a salient aspect of parental overall behaviour) may constitute another pathway affecting children's pain-related memories. Indeed, parents who use more pain words while reminiscing about a past surgery have children who develop more negatively biased pain memories (Noel et al., 2019). Parents who highly catastrophize about child pain demonstrate more pain attending verbalizations and have children reporting more negatively biased pain memories, supporting the notion that parental pain attending verbalizations and child pain memories are related (Caes, Vervoort, Trost, & Goubert, 2012; Noel, Rabbits, et al., 2015). However, findings are preliminary. Furthermore, it remains to be assessed whether *non-pain attending* verbalizations, characterized by talk that does not focus upon the child's pain, and associated with more beneficial child outcomes, buffer against the emergence of child negatively biased pain-related memories (Blount et al., 1997; Chambers, Craig, & Bennett, 2002; Walker et al., 2006). Additionally, provided that parental pain and non-pain attending verbalizations are considered to either direct child attention towards or away from pain, it remains likewise to be assessed whether such verbalizations modulate (i.e. strengthen or buffer) the impact of child pain-related attention bias upon child pain memory.

This study examined the impact of child pain-related attention bias and parental (non-)pain attending verbalizations upon child pain-related memories. Children's eye movements towards symbolic representations of pain (i.e. facial pain displays) were tracked allowing to measure attentional processes over time (see also Heathcote et al., 2017; Vervoort, Trost, Prkachin, & Mueller, 2013). This is particularly relevant since memory development is thought to rely more on elaborative processing, and hence attention maintenance as opposed to initial selection (Cowan, 1998). We hypothesized that child negatively biased pain memories would be enhanced for (a) children demonstrating higher pain-related attention bias (particularly maintained attention) and (b) parents demonstrating higher pain attending and lower non-pain attending verbalizations. We also expected that (c) the relationship between child pain-related attention and memory biases would be enhanced when parents demonstrated high levels of pain attending verbalizations and buffered when demonstrating high levels of non-pain attending verbalizations. Furthermore, as an additional aim and replication of previous research (Noel et al., 2012a), we explored whether child negatively biased pain memories would enhance children's expectations of future pain.

2 | METHOD

2.1 | Participants

This study is part of a larger study protocol aimed at examining two distinct research questions. The first part of the study protocol examined the link between child attention bias, child memory bias for pain and pain-related fear and the moderating role of parental (non-)pain attending verbalizations in those relationships, whereas the second part aimed at investigating the impact of parental perspective-taking upon various parental affective-behavioural responses. This manuscript reports the results of the first part. The method section is restricted to the tasks relevant to this study. Procedures relevant to the second part of the study occurred independently from the methodology described in this manuscript and are thus not expected to interfere with the current results.

Participants were recruited from a sample of school children (age range: 8–16 years) and both their parents who had participated in an earlier questionnaire study (Baert et al., 2019), and had provided informed consent to be re-contacted for future research participation ($N = 198$). Participants had originally been recruited via 9 Flemish primary and secondary schools. Participants were re-contacted by phone. School children between the age of 8 and 16 were invited to participate in this study, as well as one of their parents. Exclusion criteria of this study were as follows: (a) children experiencing recurrent or chronic pain, (b) children with a diagnosis of a developmental disorder, (c) children and/or parents with insufficient knowledge of the Dutch language since all questionnaires and instructions were in Dutch, (d) children outside the age range of 8–16 years. In case parent–child interaction would occur in a language other than Dutch, parent–child dyads would be excluded after study completion. Eventually, 188 children and their parents were contacted either by phone ($N = 176$) or by email ($N = 12$). Of the contacted dyads, 84.8% ($N = 168$) met the inclusion criteria and 47% of them ($N = 88$) agreed to take part in the study. Power analysis indicated that a sample size of 60–70 participants was sufficient to detect a medium effect with power 0.80 using $\alpha = 0.05$, two-tailed. Eight dyads who initially agreed, withdrew from later participation. The main reasons for withdrawal were a lack of time, distance to the laboratory and other family responsibilities. The final sample included 80 parent–child dyads. The average age of participating children was 12.8 years ($SD = 2.21$; age range = 8–16). Children were recruited from the 3rd (8.8%), 4th (7.5%), 5th (8.8%), 6th (7.5%), 7th (16%), 8th (23.8%), 9th (16%) and 10th (11.3%) grade. The sample included an approximately equal number of boys ($N = 39$) and girls ($N = 41$). All participants had Belgian nationality. Children were primarily accompanied by their mother ($N_{mothers} = 61$; $N_{fathers} = 19$). The study received ethical approval by the Ethical Committee of the Faculty of Psychology and Educational Sciences of Ghent University. Participants gave their informed consent/assent and were informed that they could end their participation at any given moment. Each parent–child dyad was compensated 30€ for their participation in the study.

2.2 | Study overview

The study protocol comprised two phases. The first phase took place at a laboratory of the Faculty of Psychology and Educational Sciences of Ghent University, where children first performed an eye tracking task to investigate their attention for pain-related stimuli. In addition, children performed a pain-inducing task (i.e. cold pressor task; CPT), whereas their parents were watching from an adjacent room. After the CPT, children rated their experienced level of pain intensity and pain-related fear. Then, parents and children were reunited and left alone for 3 min during which parental and child verbal interactions were videotaped allowing to assess parental and child (non-)pain attending verbalizations. The second phase of the study took place 2 weeks later, when children were interviewed concerning their CPT-related pain and fear memories via the telephone.

2.3 | Measures

2.3.1 | Pain-inducing task

The CPT was used as an experimental technique to induce pain in children. Prior to the task, children were first asked to immerse their hand for 2 min in a tank containing water at room temperature (i.e. 21°C), in order to standardize skin temperature of all children. Children were then instructed to submerge their left hand up to the wrist fold into water of 10°C. They were asked to hold their hand in the water until the researcher told them to stop (i.e. after a 4-minute time limit of which children were uninformed), but were told that they could remove their hand from the water at any given time if they could no longer endure the pain. A pump within the tank circulated the water to prevent local warming around the children's immersed hand. The CPT is considered to be well suited for inducing pain sensations in children (von Baeyer, Piira, Chambers, Trapanotto, & Zeltzer, 2005; Birnie, Petter, Boerner, Noel, & Chambers, 2012). This procedure is analogous to CPT procedures used in previous research (Heathcote et al., 2017; Noel et al., 2012a; Vervoort et al., 2011; Vervoort, Trost, Sütterlin, Caes, & Moors, 2014).

2.3.2 | Experienced pain intensity and pain-related fear

In line with previous research on children's memory for pain, we assessed both child memory for sensory (i.e. pain intensity) and affective (i.e. fear) aspects of the painful event (i.e. the Cold Pressor Task). Pain intensity was assessed using the Faces Pain Scale Revised (FPS-R; Hicks, von Baeyer, Spafford, van Korlar, & Goodenough, 2001). The FPS-R is a self-report measure used to measure experienced pain intensity among children. The scale comprises a single item which shows 6 faces that express varying degrees of pain, ranging from 'no pain' to 'most pain possible'. Immediately after completion of the CPT, children were asked to circle the face that best expresses their own pain experience during the CPT, generating scores from 0 to 5. The FPS-R has good psychometric properties, is considered the most suited method for measuring acute pain intensity in children aged 4 years and up (Hicks et al., 2001; Stinson, Kavanagh, Yamada, Gill, & Stevens, 2006) and has previously been used in Dutch samples (Brands, Purperhart, & Deckers-Kocken, 2011).

Children's experienced fear was assessed using the Children's Fear Scale (CFS). The CFS is a self-report questionnaire that was adapted from the adult Faces Anxiety Scale (McKinley, Coote, & Stein-Parbury, 2003) and measures pain-related fear among children (McMurtry, Noel, Chambers, & McGrath, 2011). The CFS comprises a single item, which shows five faces of children expressing varying degrees of pain-related fear. Immediately after the CPT, children were asked to circle the face that best expresses the amount of fear they experienced in regard to the painful CPT experience. Faces are scored from 0 to 4. The CFS shows preliminary evidence for good psychometric properties, as test–retest and interrater reliability, as well as construct validity among children was demonstrated (McMurtry et al., 2011). Both the FPS-R and CFS have previously been used to assess pain and fear experience and subsequent recall in clinical and experimental studies of pain memory in children (Noel et al., 2012a, 2019; Noel, McMurtry, Chambers, & McGrath, 2010). Both scales are suitable for universal use as the faces display no ethnic features and are sex and age neutral.

2.3.3 | Free viewing task and stimulus materials

Pain-related attention bias in children was investigated by means of a free viewing task during which participants were requested to freely view a series of picture pairs comprising a neutral child expression paired with either a low, moderate or high painful facial expression. Stimulus materials for the free viewing task comprised 40 pictures of 10 different children displayed in grayscale ($N_{boys} = 5$, $N_{girls} = 5$, age range = 9–16 years). Each of these children showed four different levels of pain expression: (a) no pain expression, (b) low pain expression, (c) moderate pain expression and (d) high pain expression. All pictures were generated in earlier research where children underwent a CPT (Vervoort et al., 2011), hence representing genuine child pain expressions. The pictures have previously been coded in terms of expressed pain intensity using the Child Facial Coding System (Chambers, McGrath, Gilbert, & Craig, 1996) and have repeatedly been used in previous research assessing attention to pain (Vervoort et al., 2011; Vervoort, Trost, & Van Ryckeghem, 2013). Each child was presented with three different pairs of pictures; that is a picture pair whereby the child had a no-pain expression combined with either a picture of the same child expressing a low, moderate or high level of pain. Combining the three types of pictures, 30 slides were generated. The stimulus set with picture pairs reflecting varying levels of facial pain expressiveness allowed to examine whether child-pain-related attention varies with level of pain expressiveness (i.e. low, moderate or high) and allowed to capture attention towards a broad range of pain experiences as they occur for children in daily life (i.e. ranging from mild to high pain) rather than just one level of pain intensity. Each pair of pictures was presented twice so that the no-pain expression picture was presented on both the left and right side. Pictures were 16 cm high, 10 cm wide and were separated by 4.4 cm from each other. The validity of the present stimulus material is substantiated by previous findings indicating that increasing levels of facial pain expression correlated with the observers' increasing pain ratings (Vervoort, Trost, Prkachin, et al., 2013; Vervoort, Trost, & Van Ryckeghem, 2013).

Eye movements of children were registered with a 300-Hz Tobii (TX300) eye tracker (Tobii Technology AB) while performing this viewing task. This system is composed of a 17-inch computer screen in which 10 cameras and infrared LED optics are installed. Eye movements were registered based on the reflection of the infrared light source on the eye's cornea. Children were seated at a 50–65 cm distance from the computer screen. Children were presented with an overview of the trial on paper to ensure familiarity with the experimental design. A standardized calibration procedure was performed first, where children were asked to track 9 sequentially appearing red dots that were presented at random positions on the screen. Following valid calibration, the actual free viewing task was initiated. During this task, each child was presented with a series of picture pairs with both a no-pain and painful expression of another child. To increase *personal salience* of picture stimuli, participating children were told that the children in the pictures had performed the same pain task as they would have to subsequently perform (see also Heathcote et al., 2017). Furthermore, children were instructed to fixate on a white cross that would appear in the middle of the screen in between the presentation of the picture pairs and to freely look at the pictures in any way they wanted to during their presentation. No other task instructions were given. Each trial began with the presentation of the white fixation cross in the centre of the screen for 500 ms. Next, a picture pair was presented on a grey background for 3,500 ms. The inter-trial-interval had a duration of 200 ms. Each child was presented with 60 trials in randomized order. Two eye movement parameters were calculated to measure attention bias: (a) *probability of initial fixation* and (b) *gaze duration* (i.e. total fixation duration). See 2.5.1 (data reduction) for a full description of these parameters.

2.3.4 | Parent–child interaction

Videotapes of the 3-minute interaction between parents and children were transcribed and divided into independent child and parental utterances which were coded based upon the coding procedure developed by Walker et al. (2006) and used in previous research by Vervoort et al. (2011) Parental and child utterances were coded as either (a) pain attending utterances, (b) non-pain attending utterances and (c) other. Pain attending utterances were defined as parental or child utterances that focus upon child pain experience and the cold pressor task (e.g. ‘Did it hurt a lot’?, ‘My hand felt totally numb’). Non-pain attending utterances were defined as parental or child utterances that did not focus upon the child's pain experience or the CPT procedure (e.g. ‘What are we going to eat tonight’?, ‘Do you still have schoolwork’?). Parental and child utterances were coded as ‘other’ if they were inaudible or related to technical aspects of the procedure (e.g. ‘Do you think we can go home soon’?). All transcripts were coded by a primary coder. To calculate inter-rater reliability, a second independent coder coded 25% of the transcripts, which were randomly selected. In line with Walker et al. (2006), intra-class correlations were used to determine inter-rater reliability for each of the coding categories. In this study, coefficients ranged between 0.73 and 0.89 indicating good to excellent inter-rater reliability for all coding categories. Within this study, four proportion scores were calculated for further analyses. ‘Parental pain attending verbalizations’ were calculated as the number of parental pain attending utterances divided by the total number of parental utterances, whereas ‘parental non-pain attending verbalizations’ were calculated as the number of parental non-pain attending utterances divided by the total number of parental utterances. Likewise, ‘child pain attending verbalizations’ and ‘child non-pain attending verbalizations’ were calculated as the number of child pain and non-pain attending utterances, respectively, divided by the total number of child utterances.

2.3.5 | Memory and expectancies interview

The memory and expectancies interview took place 2 weeks after the initial laboratory session and was conducted in line with the memory assessment protocol of Noel et al. (2012a) Specifically, children were instructed, using the FPS-R (Hicks et al., 2001) and CFS (McMurtry et al., 2011), to rate (a) how much pain intensity and pain-related fear they remembered having experienced during the CPT and (b) how much pain intensity and pain-related fear they expected they would experience if they had to perform the CPT once again. To facilitate communication by telephone and to avoid the introduction of a possible confounding numeric scale, each face of the FPS-R and CFS was ascribed a random letter of the alphabet (instead of a possible confounding numerical scale), which children had to mention aloud to indicate the face of their choice. The letters were placed directly under the faces on the scales, in a random order. This method allows the researcher to orient the child to the specific faces over the telephone, thus facilitating ease of communication via telephone. This procedure has been used in previous research conducting memory interviews (Badali, Pillai, Craig, Giesbrecht, & Chambers, 2000; Noel et al., 2010, 2012a, 2019). Using the FPS-R, children were requested to report (a) how much pain intensity they had experienced during the CPT (i.e. memory for experienced pain) and (b) how much pain intensity they expected to experience during a hypothetical future CPT (i.e. pain expectancy). Using the CFS, children were requested to report on (a) how much pain-related fear they had experienced during the CPT (i.e. memory for experienced fear) and (b) how much pain-related fear they expected to experience during a hypothetical future CPT (i.e. fear expectancy).

2.4 | Procedure

Children and the accompanying parent were invited to the research facilities of Ghent University where the laboratory session of the study was conducted. Upon arrival at the research facility, participants were accompanied by two experimenters (both female) and told that they would engage in a study examining how children and their parents react to the experience of child pain. They were told that the child would perform a computerized task and complete a number of questionnaires. Furthermore, they were shown the CPT apparatus and were informed about the pain task that the child would perform, whereas parents would watch the child from an adjacent room. Hereto, the images of a camera recording the child's facial pain behaviour during CPT performance were streamed on a television screen in the observer-room where the parent was seated. All participants were asked to sign an informed consent/assent form. The child stayed in the laboratory together with one of the experimenters, whereas the parent was accompanied to an adjacent room by the other experimenter. Children then completed the free viewing task to assess attention for pain-related stimuli. After completion of the free viewing task, children were requested to perform the CPT, whereas their parent was asked to watch their child perform the CPT. Immediately upon completion, children were asked to rate their experienced pain and fear during the CPT using the FPS-R and CFS, respectively. Next, parents were reunited with their child in the child test room, and left alone for a fixed time interval of 3 min. During this 3-minute time interval, parent–child interaction was videotaped. Parent and child were not informed in advance about the video recording of their interactions in order to capture spontaneous behaviours. At study completion, children and parents were debriefed about the purpose of the study and asked to sign an additional consent/assent form for the use of the video data. Furthermore, parents and children were given a sealed envelope with questionnaires and were told that a researcher would contact them 2 weeks later by telephone to ask some further questions. Participants were asked not to open the envelope until the phone interview and thus did not know beforehand their memories about the pain task would be elicited. Two weeks later, children were phoned by a researcher and asked to report on their pain and fear memories as well as their future pain and fear expectancies using the FPS-R and CFS, respectively. A 2-week time frame was employed in accordance with other studies conducting memory interviews (Noel et al., 2010, 2012a; Pate et al., 1996).

2.5 | Data reduction

2.5.1 | Eye movement parameters

Child attention to pain was analysed with the Tobii Software analysis package using the Identification Velocity-Treshold (I-VT) filter (classifier: 30°/s; Velocity calculator window length: 20 ms). The I-VT fixation classifier is based on the Velocity-Treshold Identification fixation filter (Komogortsev, Gobert, Jayarathna, Koh, & Gowda, 2010; Salvucci & Goldberg, 2000). In each trial, eye movements were monitored for the two target pictures who were considered the areas of interest (AOI), that is pictures of a neutral child expression paired with a picture of the same child displaying either a low, moderate or high painful facial expression (see 3.2). Fixations on AOIs were defined as gaze that remained stable within a 1° visual angle and that lasted at least 100 ms (Todd, Sharpe, Colagiuri, & Khatibi, 2016; Vervoort et al., 2014; Yang, Jackson, Gao, & Chen, 2012). In line with Heathcote et al. (2017), two eye movement parameters were calculated for each trial: (a) *probability of initial fixation* and (b) *gaze duration* (i.e. total fixation duration). *Probability of initial fixation* was defined as the likelihood that children would first fixate their eye gaze on either the no-pain or (low, moderate or high) pain face. Children showed an initial *fixation bias to pain* when they made first fixations at the beginning of the trials on the pain faces (i.e. either low, moderate or high pain expressions) more often than on the no-pain face counterparts. An initial fixation bias was calculated by computing the proportion of all trials where children focused their initial attention (i.e. made the initial visual fixation) on pain faces rather than on no-pain faces (with proportion scores >0.5 indicating an initial fixation bias towards pain faces, scores = 0.5 indicating no bias and scores <0.5 indicating an initial fixation bias away from pain faces). An initial fixation bias index was calculated separately for each facial pain expression category, resulting in three indices of initial fixation bias. The second eye movement parameter, *gaze duration*, was defined as the total time children focused their attention (i.e. the total duration of visual fixations made) on either no-pain or pain faces (also referred to as attentional maintenance) and was computed for each facial pain expression separately (i.e. no pain, low, moderate or high pain face expression). *Gaze duration bias* was defined as fixating more on pain faces than on no-pain faces (namely, the total time fixating on each type of pain face (i.e. low, moderate or high pain face) minus the total time fixating on their no-pain face counterparts during the whole 3,500 ms face pair presentation), with scores >0 indicating a biased gaze duration towards pain faces, scores = 0 indicating no bias and scores <0 indicating a biased gaze duration away from pain faces.

In order to derive indices for the main analyses testing our hypotheses, *averages* across the three expressiveness levels (i.e. low, moderate and high expression) were calculated for each of the two types of attention bias indices (i.e. probability of initial fixation and gaze duration), resulting in one mean index for initial fixation bias and one mean index for gaze duration bias, respectively. This is justified since (a) no a priori hypotheses were formulated regarding the potentially differential impact of attention bias to various levels of pain expressiveness, (b) this study wanted to capture effects for all levels of pain expressiveness in children as they occur for children in daily life (i.e. ranging from mild to high pain), (c) tripling the amount of analyses would increase the possibility of a Type I error and (d) data exploration showed that findings were similar for all levels of pain expressiveness.

2.5.2 | Memory bias indices

Pain memory bias was calculated as the difference between recalled pain intensity (measured by the FPS-R 2 weeks after the CPT) and experienced pain intensity as reported by the child (measured by the FPS-R directly after the CPT). Biased pain memories or overestimation of pain was defined as recalling pain intensity 2 weeks after the laboratory session as worse (i.e. higher) than initially reported (i.e. a positive value), whereas underestimation and accurate estimation of pain were defined as recalling less pain than initially reported or recalling the same amount of pain (i.e. zero or a negative value), respectively. Likewise, *fear memory bias* was calculated as the difference between recalled pain-related fear (measured by the CFS 2 weeks after the CPT) and experienced pain-related fear by the child (measured by the CFS directly after the CPT). Overestimation of fear was defined as recalling pain-related fear 2 weeks after the laboratory session as worse (i.e. higher) than initially reported (i.e. a positive value), whereas underestimation and accurate estimation of fear were defined as recalling less pain-related fear than initially reported or recalling the same amount of pain-related fear (i.e. zero or a negative value), respectively.

2.6 | Statistical analyses

Correlational and regression analyses were conducted with the statistical software SPSS version 24 (SPSS IBM). Significance levels were set at 0.05. Pearson correlations were used to examine the relations between child attention biases (i.e. initial fixation bias and gaze duration bias), parental (non-)pain verbalizations, child (non-)pain verbalizations, pain memory bias, fear memory bias, pain expectancy and fear expectancy. Next, hierarchical linear regressions were performed to investigate the impact of child attention bias to pain on both child pain intensity and pain-related fear memory biases as well as the moderating role of parental pain and non-pain attending verbalizations for these relationships. Hereto, a series of regression analyses were performed separately for each independent variable (i.e. initial fixation bias and gaze duration bias), each moderator variable (i.e. parental pain attending and non-pain attending verbalizations) and each outcome variable (i.e. pain memory bias pain and fear memory bias). Moderation analyses followed the procedures outlined by Holmbeck (1997), that is (a) continuous predictor variables were centred and (b) significant interactions were investigated by plotting and testing the significance of the regression lines for high (+1 SD above the mean) and low (−1 SD below the mean) values of the continuous moderator variable (i.e. parental pain attending or non-pain attending verbalizations). To partial out the impact of demographic variables upon child pain/fear memory or expectancies, we controlled for the child's age and sex in the first step of each regression analysis. Child pain or non-pain attending verbalizations were not entered in the final regression models because of problems of multicollinearity (i.e. VIF >2). Child attention biases (i.e. either initial fixation bias or gaze duration bias) and parental verbalizations (i.e. either pain attending or non-pain attending) were entered in a second block of the hierarchical regression analysis, whereas the cross-product terms of these variables were entered in a third block (Baron & Kenny, 1986). As an additional aim, two regression analyses were performed, investigating the impact of child pain and fear memory bias on child pain and fear expectancies, respectively. Child age and sex were entered in step 1 of the regression analysis, child pain or fear experience was entered in step 2 to control for initially reported child pain and fear, respectively and memory bias for pain or fear was entered in a third step. Variance-inflation factors of all regression analyses reported below were acceptable (range 1.00–1.69), suggesting that there was no problem of multicollinearity (Myers, 1990).

3 | RESULTS

3.1 | Participant characteristics

Data from 26 children were discarded from analyses due to sub-optimal overall attention track status (i.e. eye movements tracked less than 70% of total task viewing time; Heathcote et al., 2017). This drop-out is in line with previous eye tracking studies (see e.g. Heathcote et al., 2017; Vervoort, Trost, Prkachin, et al., 2013). Furthermore, data of the parent–child interaction could not be used for three parent–child dyads, as two parent–child dyads talked about their experiences in a foreign language and one child left the testing room. The final sample used in analyses and reported below therefore included 51 children ($N_{boys} = 25$, $N_{girls} = 26$; $M = 13.27$ years; $SD = 1.90$ years; Range = 9–16 years) and 51 parents ($N_{mothers} = 38$, $N_{fathers} = 13$, $M = 45.63$ years; $SD = 6.52$; Range = 34–68 years). Independent samples t tests indicated none of the outcome variables differed between those parent–child dyads who were excluded from the analyses ($N = 29$) and those who were not ($N = 51$; all $|t|(76) \leq 1.66$, ns). Results furthermore indicated that child and parental pain attending verbalizations did also not differ between both samples (both $|t|(74) \leq 0.63$, ns). However, both parental and child non-pain attending verbalizations were significantly lower in the sample that was excluded from the analyses ($M_{parent} = 0.06$, $SD = 0.06$; $M_{child} = 0.06$, $SD = 0.10$) and the sample that was not ($M_{parent} = 0.13$, $SD = 0.14$; $M_{child} = 0.12$, $SD = 0.13$; $t_{parent}(74) = -3.27$, $p < .01$ and $t_{child}(74) = -2.23$, $p < .05$).

One sample t tests were conducted to investigate whether there were absolute child attention biases (i.e. initial fixation bias index significantly different from 0.5 and gaze duration bias index significantly different from 0). Results showed a significant initial fixation bias towards pain faces ($M = 0.52$, $SD = 0.06$; $t(50) = 2.30$, $p < .05$), indicating that children showed a significantly higher likelihood to first fixate on the pain face. There also was a significant gaze duration bias towards pain faces ($M = 4.38$, $SD = 5.35$; $t(50) = 5.85$, $p < .001$) indicating that children maintained their attention significantly longer towards pain faces than neutral pain faces. Two repeated measures ANOVAs were conducted to further investigate the nature of initial and maintained attention biases (i.e. whether attention bias varied depending upon levels of pain expressiveness; i.e. low, moderate, high pain expression). For initial fixation bias, there was no significant difference between the three levels of pain expressiveness ($F(2,100) = 1.87$, ns), indicating that the likelihood to first fixate on the pain face was similar for all levels of pain expressiveness. For gaze duration bias, there was a significant effect of level of pain expressiveness ($F(2,100) = 5.39$, $p < .01$), indicating that the likelihood to maintain attention towards pain faces varied across the different levels of expressiveness. Additional contrast analyses revealed that gaze duration bias towards low ($M = 2.97$; $SD = 4.48$) and moderate ($M = 4.18$; $SD = 7.23$) facial pain expressiveness did not significantly differ from each other ($F(1,50) = 1.72$, ns). Gaze duration bias towards moderate pain expression was significantly lower than gaze duration bias towards high facial pain expressiveness ($M = 5.98$; $SD = 7.52$; $F(1,50) = 4.51$, $p < .05$). One sample t tests were performed to examine whether there were absolute pain and fear memory biases. Findings indicated a significant pain memory bias in the current sample ($M = -0.39$, $SD = 0.92$; $t(50) = -3.05$ $p < .01$), indicating that participants generally underestimated and thus remembered lower levels of pain than initially reported. No evidence for fear memory bias was observed ($M = 0.00$, $SD = 0.77$; $t(50) = 0.00$, ns).

Mean scores, standard deviations and Pearson correlation coefficients for all independent and dependent variables of interest are presented in Table 1. Note that average scores (i.e. averaged across the 3 expressiveness levels) for first fixation bias and gaze duration bias are reported here as no a priori hypotheses were formulated regarding the impact of attention bias to various levels of pain expressiveness (See also 2.5.1). Pearson correlation analyses indicated that pain and fear memory bias were positively but not significantly correlated ($r = .25$, $p = .07$). Child attention biases (i.e. initial fixation bias and gaze duration bias) were significantly positively correlated with each other ($r = .33$, $p < .05$), but not with any of the memory biases (all $r \leq .22$, ns). Initial fixation bias was significantly positively correlated with child pain attending verbalizations ($r = .36$, $p < .05$) and significantly negatively associated with child and parental non-pain attending verbalizations ($r_{child} = -.29$, $p = .04$; $r_{parent} = -.44$, $p < .01$), indicating that children who fixated their initial attention more on pain faces, also talked more about their pain experience. Furthermore, child non-pain attending verbalizations were significantly negatively correlated with pain memory bias ($r_{child} = -.30$, $p < .05$) indicating that higher levels of child non-pain attending verbalizations are associated with more underestimation of pain. Pain and non-pain attending verbalizations were significantly negatively associated in children ($r = -.31$, $p < .05$) and in parents ($r = -.46$, $p < .01$). There was a strong significant and positive correlation between corresponding parental and child pain and non-pain attending verbalizations (both $|r| \geq .78$, $p < .01$). Non-corresponding parental and child pain and non-pain attending verbalizations were significantly negatively correlated with each other (both $|r| \geq .35$, $p < .05$). Child pain expectancies significantly correlated with child fear expectancies ($r = .64$, $p < .01$), but both did not significantly correlate with pain or fear memory bias (both $r \leq .20$, ns).

3.2 | The role of child probability of initial fixation bias to pain and the moderating role of parental pain and non-pain attending verbalizations

Results of hierarchical linear regression analyses investigating the impact of initial fixation bias to pain upon *pain memory bias* and *fear memory bias* and the moderating role of parental *pain attending* verbalizations can be found in Table 2. No significant main or interaction effects were observed (all $|\beta| \leq 0.28$, ns).

Hierarchical linear regression analyses (see Table 2) investigating the impact of initial fixation bias to pain and the moderating role of parental *non-pain attending* verbalizations upon *pain memory bias and fear memory bias* likewise revealed no significant main or interaction effects (all $|\beta| \leq 0.27$, ns).

TABLE 1 Number of valid cases (*N*), Means (*M*), Standard Deviations (*SD*) and Pearson intercorrelations of all measures

	N	*M* (*SD*)	2	3	4	5	6	7	8	9	10
1. Pain memory bias	51	−0.39 (0.92)	0.25	0.05	0.16	0.06	0.08	0.10	0.07	−0.16	−0.30*
2. Fear memory bias	51	0.00 (0.77)	—	0.19	0.20	0.06	0.22	−0.01	−0.00	0.11	0.02
3. Pain expectancy	51	1.47 (1.08)		—	0.64**	−0.11	0.20	0.03	−0.01	0.01	0.02
4. Fear expectancy	51	0.49 (0.78)			—	0.19	0.18	−0.04	0.02	−0.02	−0.01
5. Probability of initial fixation	51	0.52 (0.06)				—	0.33*	0.25	0.36*	−0.44**	−0.29*
6. Gaze duration	51	4.38 (5.35)					—	−0.10	−0.07	−0.13	−0.07
7. Parental pain attending verbalizations	51	0.56 (0.19)						—	0.78***	−0.46**	−0.40**
8. Child pain attending verbalizations	51	0.54 (0.20)							—	−0.35*	−0.31*
9. Parental non-pain attending verbalizations	51	0.13 (0.14)								—	0.91***
10. Child non-pain attending verbalizations	51	0.12 (0.13)									—

*$p < .05$;
**$p < .01$;
***$p < .001$.

3.3 | The role of child gaze duration bias to pain and the moderating role of parental pain and non-pain attending verbalizations

Hierarchical linear regression analyses (see Table 3) investigating the impact of gaze duration bias to pain upon *pain memory bias* and *fear memory bias* and the moderating role of parental *pain attending* verbalizations indicated a significant main effect of child age ($\beta = 0.29$, $p < .05$) on pain memory bias, indicating that older children underestimate their pain less than younger children. Counter to expectations, no other significant main or interaction effects were observed (all $|\beta| \leq 0.28$, ns).

Hierarchical linear regression analyses (see Table 3) investigating the impact of gaze duration bias and the moderating role of parental *non-pain attending* verbalizations revealed a significant effect of child sex upon pain memory bias ($\beta = -0.30$, $p < .05$), indicating that boys in the current sample underestimate their pain less compared to girls. No other significant main effects or interaction effects were

TABLE 2 Results of hierarchical regression analyses explaining the role of child probability of initial fixation to pain and the moderating role of parental pain and non-pain attending verbalizations

Criterion variable	Step	Predictor	β	ΔR^2	Adjusted R^2
Pain memory bias	1	Child age	0.28	0.13*	0.10
		Child sex	−0.24		
	2	Initial fixation	0.01	0.01	0.07
		Parental pain attending verbalizations	0.10		
	3	Parental pain attending verbalizations × initial fixation	−0.08	0.01	0.06
Fear memory bias	1	Child age	0.09	0.05	0.01
		Child sex	−0.20		
	2	Initial fixation	0.03	0.01	−0.03
		Parental pain attending verbalizations	−0.05		
	3	Parental pain attending verbalizations × initial fixation	−0.10	0.01	−0.04
Pain memory bias	1	Child age	0.22	0.13*	0.10
		Child sex	−0.27		
	2	Initial fixation	0.03	0.01	0.07
		Parental non-pain Attending verbalizations	−0.16		
	3	Parental non-pain attending verbalizations × initial fixation	−0.13	0.01	0.06
Fear memory bias	1	Child age	0.13	0.05	0.01
		Child sex	−0.21		
	2	Initial fixation	0.15	0.04	0.01
		Parental non-pain attending verbalizations	0.25		
	3	Parental non-pain attending verbalizations × initial fixation	0.08	0.01	−0.01

Note: Standardized regression coefficients (β) from the last step of the analyses are displayed.

*$p < .05$;

**$p < .01$;

***$p < .001$.

observed for pain memory bias as outcome variable (all $|\beta| \leq 0.24$, ns). However, while there were also no significant main effects for fear memory bias as outcome variable, we observed a significant gaze duration bias × parental non-pain attending verbalizations interaction effect for fear memory bias ($\beta = -0.46$, $p < .01$).

To interpret the observed interaction, we plotted regression lines for low (−1 SD below the mean) and high (+1 SD above the mean) values of the moderator variable (Holmbeck, 1997). The analyses with *fear memory bias* as outcome variable indicated a cross-over interaction suggesting that the impact of gaze duration bias upon fear memory bias depends upon whether parents engage in high or low levels of non-pain attending verbalizations. Indeed, inspection of regression lines and corresponding coefficients depicted in Figure 1 indicated that higher levels of child gaze duration bias to pain were significantly positively associated with more fear memory bias (i.e. overestimation of fear), but only

TABLE 3 Results of hierarchical regression analyses explaining the role of child gaze duration to pain and the moderating role of parental pain and non-pain attending verbalizations

Criterion variable	Step	Predictor	β	ΔR^2	Adjusted R^2
Pain memory bias	1	Child age	0.29*	0.13*	0.10
		Child sex	−0.28		
	2	Gaze duration	0.12	0.03	0.09
		Parental pain attending verbalizations	0.12		
	3	Parental pain attending verbalizations × gaze duration	−0.10	0.01	0.08
Fear memory bias	1	Child age	0.06	0.05	0.01
		Child sex	−0.27		
	2	Gaze duration	0.27	0.07	0.04
		Parental pain attending verbalizations	0.01		
	3	Parental pain attending verbalizations × gaze duration	0.01	0.01	0.02
Pain memory bias	1	Child age	0.24	0.13*	0.10
		Child sex	−0.30*		
	2	Gaze duration	0.20	0.02	0.08
		Parental non-pain attending verbalizations	−0.03		
	3	Parental non-pain attending verbalizations × gaze duration	0.16	0.02	0.08
Fear memory bias	1	Child age	0.08	0.05	0.01
		Child sex	−0.20		
	2	Gaze duration	0.03	0.10	0.07
		Parental non-pain attending verbalizations	−0.01		
	3	Parental non-pain attending verbalizations × gaze duration	−0.46**	0.12**	0.19

Note: Standardized regression coefficients (β) from the last step of the analyses are displayed.

*$p < .05$;

**$p < .01$;

***$p < .001$.

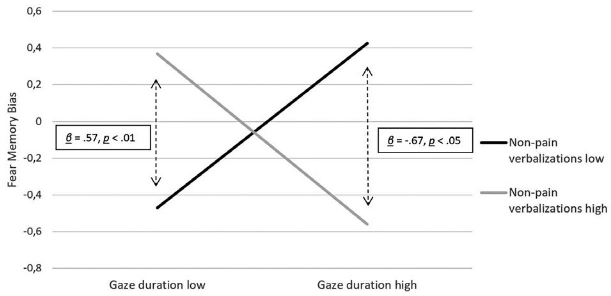

FIGURE 1 Child fear memory bias as a function of low (−1 SD below the mean) and high (+1 SD above the mean) levels of child gaze duration and parental non-pain verbalizations

among those children whose parents demonstrated *low* levels of non-pain attending verbalizations ($\beta = 0.58$, $p < .01$). Conversely, higher levels of child gaze duration bias to pain were significantly negatively associated with fear memory bias (i.e. underestimation of fear) among children whose parents demonstrated *high* levels of non-pain attending verbalizations ($\beta = -0.60$, $p < .05$). Accordingly, these findings suggest a buffering role of higher levels of parental non-pain attending verbalizations for the emergence of overestimation of fear and a vulnerability for an enhanced fear memory bias in case of lower levels of parental non-pain attending verbalizations. However, the pattern of findings displayed in Figure 1 suggests some caution is needed when drawing such conclusion. In particular, additional analysis *within* the group of children who demonstrated 'high gaze duration bias to pain' showed that higher levels of parental non-pain attending verbalizations were associated with *lower* levels of fear memory bias (i.e. more underestimation of fear; $\beta = -0.67$, $p < .05$; dotted line in Figure 1). However, the reverse pattern was observed *within* the group of children who demonstrated 'low gaze duration bias to pain' with the observed negative score suggesting attentional avoidance of pain ($M_{\text{gaze duration}}$ – 1 SD = −0.97; Calvo & Avero, 2005). Within this latter group, higher levels of parental non-pain attending verbalizations were associated with *higher* levels of fear memory bias (i.e. overestimation of fear; $\beta = 0.57$, $p < .01$; dotted line in Figure 1), hence suggesting that parental non-pain attending verbalizations serve a buffering role when the child demonstrates high attentional maintenance to pain but not when the child demonstrates low attentional maintenance of pain.

3.4 | The role of child pain and fear memory bias for future pain and fear expectancies

Results of the regression analyses with future pain expectancy as outcome variable (see Table 4) indicated that both pain and fear memory bias contributed to worse pain and fear expectancies, respectively, for future pain events (i.e. if children would have to perform the same cold pressor task again). Analyses revealed that, even after controlling for experienced pain (which also contributed to pain memory bias [$\beta = 0.85$, $p < .001$]), more pain memory bias (i.e. overestimating experienced pain) predicted more pain expectancy ($\beta = 0.40$, $p < .01$). Likewise, after controlling for experienced pain-related fear, which contributed to fear memory bias ($\beta = 0.49$, $p < .01$), more fear memory bias (i.e. overestimating experienced fear) contributed to more fear expectancy ($\beta = 0.33$, $p < .05$).

4 | DISCUSSION

This study was the first to investigate the impact of child attention bias to pain and parental (non-)pain attending verbalizations on child pain and fear memory bias for experimental pain. Eye tracking methodology was employed to dynamically measure child attention bias over time allowing to assess initial attentional capture by pain and attentional maintenance. Findings were partially in line with expectations and can be readily summarized. Specifically, and counter to expectations, no main effects of child attention bias indices and parental pain and non-pain attending verbalizations for child memory biases were observed. Yet, parental verbalizations did moderate the relationship between child attention bias and memory bias. In particular, findings revealed that higher child gaze duration bias to pain was positively associated with fear memory bias (i.e. overestimation of pain-related fear), yet this effect was only observed among children whose parents demonstrated *low* levels of non-pain attending verbalizations. The opposite pattern was observed for children whose parents showed high levels of non-pain attending verbalizations. While these findings are in line with expectations, that is a buffering role of parental non-pain attending verbalizations for the emergence of overestimation of fear, additional analysis *within* the group of children who demonstrated 'high gaze duration bias to pain' showed that higher levels of parental non-pain attending verbalizations were associated with *lower* levels of fear memory bias, whereas the reverse pattern was observed *within* the group of children who demonstrated 'low gaze duration bias to pain' characterized by attentional avoidance of pain. This suggests that parental non-pain attending verbalizations serve a buffering role when the child demonstrates high attentional maintenance to pain but not when the child demonstrates attentional avoidance of pain.

The current findings are the first to highlight that characteristics of the social context, such as parental (non-)pain-related verbalizations, as well as factors related to the intra-individual experience of pain, such as child attention bias to pain, should not be studied in isolation but rather jointly, as they *interact* in their effect on the emergence of negatively biased memories of painful events. Indeed, observed findings suggest that the link between child maintained attention to

TABLE 4 Results of hierarchical linear regression analyses explaining the role of pain and fear memory bias on pain and fear expectancy

Criterion variable	Step	Predictor	β	ΔR^2	Adjusted R^2
Pain expectancy	1	Child age	0.03	0.05	0.01
		Child sex	−0.14		
	2	Experienced pain	0.85***	0.44***	0.46
	3	Pain memory bias	0.40**	0.11**	0.57
Fear expectancy	1	Child age	0.02	0.06	0.02
		Child sex	−0.27		
	2	Experienced fear	0.49**	0.14**	0.14
	3	Fear memory bias	0.33*	0.09*	0.22

Note: Standardized regression coefficients (β) from the last step of the analyses are displayed.

*$p < .05$;

**$p < .01$;

***$p < .001$.

pain as well as parental non-attending verbalizations on biased pain memories is *not fixed* (and thus not to be defined as uniformly adaptive or maladaptive). A number of tentative explanations may account for these findings. Specifically, for children demonstrating high attentional maintenance to pain, it is possible that heightened levels of parental non-pain talk immediately following the painful event draw the child's attention away from their pain and hence distract the child from pain; an attentional strategy that has previously been identified as being beneficial for pain-related outcomes (Walker et al., 2006). Supporting the notion that pain/non-pain attending verbalizations are associated with drawing attention towards/away from pain, respectively, findings from correlation analyses in this study revealed that more child attention to pain (i.e. initial fixation bias, not gaze duration bias) was associated with lower levels of child and parental non-pain verbalizations and higher levels of child pain verbalizations. The opposite effect (i.e. increased fear memory bias) of parental non-pain verbalizations was observed among children who demonstrated decreased levels of gaze duration bias to pain, that is pain-related attentional avoidance of pain. In this case, children actually avoided the pain-related information. As such, increased fear memory bias may reflect consequences of experiential avoidance (Hayes, Wilson, Gifford, Follette, & Strosahl, 1996), which has previously been found to contribute to deleterious outcomes such as lower pain tolerance and slower recovery from the painful event (Feldner et al., 2006). Indeed, it may well be that if a child's tendency to avoid (relevant) pain-related information is further strengthened by heightened levels of parental non-pain talk afterwards (i.e. distraction of previous pain experience), pain memories are increasingly negatively biased (Lautenbacher et al., 2010). While these explanations remain tentative at this point and definitely require replication, findings cautiously suggest that interventions focused upon modulating either child attention to pain or the way parents talk to their child about pain, should not proceed in a one-size-fits-all manner. In other words, the appropriate question is not 'which type of parental response or attentional style is preferable', but rather '*when* is a certain type of parental response preferable'.

Notably, while the current findings indicated that parental verbalizations moderate the relationship between child attention bias and memory bias, this effect was specific to maintained attention to pain, non-pain attending verbalizations and memory bias for pain-related fear. The finding that gaze duration bias, rather than initial fixation bias, generated this effect was in line with our expectations, as memory development is thought to rely more on elaborative processing (i.e. gaze duration instead of initial selection; Cowan, 1998). However, our finding that a (moderating) effect was not observed for parental pain attending verbalizations was unexpected. More fine-grained observational measures (see e.g. CAMPIS; Blount et al., 1989 and CAMPIS-R; Blount, Sturges, & Powers, 1990) tapping into the *diversity* of parental pain attending verbalizations (e.g. providing reassurance, providing sympathy) may be needed to shed light on specific parental behaviours that are more or less relevant to child pain-related memories. Additionally, recent evidence suggests that we should also assess *how* parents talk about a painful event. Specifically, Noel et al. (2019) found that when parents talk with their child in a more elaborative way about child pain (i.e. containing new information as opposed to repetition of previous information), negative biases in pain memories are reduced. Our finding that we only observed effects of child maintained attention to pain and parental non-pain attending verbalizations for fear memory bias and not pain memory bias corroborates previous findings indicating that psychological variables (such as child pain catastrophizing and anxiety) affects memory for the affective (e.g. fear), rather than the sensory (e.g. intensity), aspects of pain (see e.g. Noel et al., 2012a; Noel, Rabbits, et al., 2015). On the other hand, correlation analyses indicated that children who engaged in more non-pain talk had less negatively biased pain memories. These findings clearly attest to the importance of a comprehensive assessment of memory representations; that is including both sensory (e.g. pain intensity) and affective (e.g. pain-related fear) components of pain (Jaaniste et al., 2019; Ornstein, Manning, & Pelphrey, 1999), which may not only be distinct as was the case in this study (i.e. fear and pain memory bias indices were positively but not significantly correlated) but also differentially associated with child and parental variables (see also Noel, Rabbits, et al., 2015). Comprehensive and further multidimensional memory assessment is particularly important since the affective components of pain (such as fear, unpleasantness, acceptability) are sometimes considered more troubling by children than the sensory aspects of pain (Pope, Tallon, McConigley, & Wilson, 2015).

Of further interest, participants in our study showed initial fixation and maintained attention biases to pain. Furthermore, maintained attention biases towards pain became particularly pronounced with higher facial pain expressions. This was not the case for initial fixation biases, which were equally pronounced regardless of pain expressiveness levels. These findings replicate previous findings using a similar viewing task (see e.g. Heathcote et al., 2017) and may have a common evolutionary ground as it may be more adaptive to first scan for the presence/absence of threat-relevant cues, prior to full identification and independent of the threat value that is encoded after full analysis (Vervoort, Trost, Prkachin, et al., 2013).

Finally, results further showed that participants in this study generally underestimated their past pain experience. This finding is in line with previous research (Noel et al., 2012a), indicating that negatively biased memories (i.e. overestimating experienced pain) only occur in a minority of children. Yet, crucially, current findings replicate that these children who do overestimate their pain or fear experience are prone to higher pain and fear expectancies for a hypothetical future pain task, adding to the body of literature showing that child pain-related memories are important for future pain experiences.

A number of study limitations deserve consideration. First, child attention bias to pain was measured using symbolic representations of pain, that is, facial expressions of children undergoing a similar pain procedure, whereas memory bias was assessed regarding actual experienced pain stimuli. This may have reduced the strength in relationship between both biases as the presence/absence of both biases may be dependent upon the actual pain-related stimuli (Van Ryckeghem et al., 2013). Research examining the relationship between attention and memory bias for actual and similar pain stimuli is warranted. Second, we only examined parental pain and non-pain attending verbalizations, which are only a small part of the parent–child dynamics that may impact child pain-related memory. Future research should assess for other, more fine-grained, parent–child dynamics that may impact child pain-related memory, such as parental narrative style (i.e. elaboration and repetitive style; see Noel et al., 2019) parenting style and non-verbal parental behaviour (Constantin, Moline, & McMurtry, 2018; McMurtry, Chambers, McGrath, & Asp, 2010). Third, while research suggests that mothers and fathers might differ in how they talk and reminisce with their children (Fivush, Brotman, Buckner, & Goodman, 2000; Noel et al., 2019), the current sample size precluded from investigating parent role and sex differences in talking with their children and how these may differentially impact child pain-related memories. Finally, findings are limited to a healthy sample of school children. Future research should investigate whether results generalize to clinical samples.

In spite of these limitations, this study's findings are important as they are the first to shed light on potential critical intrapersonal child variables (i.e. child pain-related attention), parental variables (i.e. parental pain/non-pain attending verbalizations) and the intersection between both in understanding child pain-related memories, hence further informing existing conceptualizations of pain memory development (Noel, Chambers, Petter, et al., 2012). Future research is encouraged to replicate and expand on the current findings by further exploring suggested avenues for further research.

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DISCLOSURES

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AUTHORS' CONTRIBUTIONS

Aline Wauters was responsible for data input and data analyses, as well as the writing of the drafts and final version of the manuscript. Tine Vervoort was involved in the study design and data collection, provided thoughtful suggestions on interpretation of findings and actively contributed to writing and editing of the manuscript. Melanie Noel provided feedback on the design of the study and provided thoughtful suggestions on earlier drafts of this manuscripts. Alvaro Sanchez-Lopez analysed the eye-tracking data and actively contributed to editing of the manuscript. Dimitri Van Ryckeghem was involved in the study design, provided thoughtful suggestions regarding the theoretical conceptualization of the manuscript and interpretation of the study findings and actively contributed to editing of the manuscript.

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